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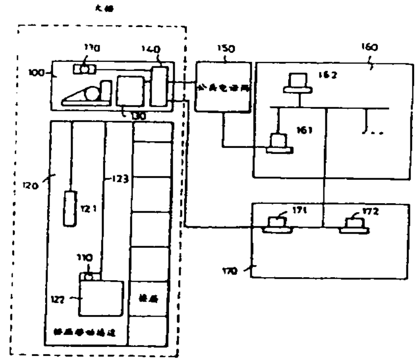
[54]发明名称 电梯耐久性评估装置及其方法

[57]摘要

一种通过测量安装电梯的大楼中的温度，湿度，粉尘，振动及噪声而精确预测电梯部件寿命的电梯耐久性评估装置。其包括设在机房和电梯轿厢中用于检测各种环境条件因素的环境条件检测传感器，用于控制电梯的控制盘，监测单元，用于把环境条件检测传感器检测到的环境条件因素和控制盘的运行信息通过公共电话网送到远程监测中心，该远程监测中心包括第一CPU，用于从监测单元采集信息并存储信息，及第二CPU，用于评估部件耐久性，诊断电梯故障，及预测部件寿命。



权　利　要　求　书

1、电梯耐久性评估装置包括:

设置在机房和电梯轿厢中用于检测环境条件因素的环境条件检测传感器装置;

用于控制电梯的控制盘装置;

监测单元装置，用于把环境条件检测传感器装置检测到环境条件因素和控制盘装置的运行信息通过一个公共电话网发送，以及

一个远程监测中心装置，它包括第一中央处理单元(CPU)，用于从监测单元装置采集信息并且存储这些信息，还有一个第二 CPU，用于评估部件的耐久性，诊断电梯的故障，以及预测部件的寿命。

2、按照权利要求 1 的装置，其中，所述环境条件检测传感器装置检测温度，湿度，以及粉尘污染程度。

3、按照权利要求 1 的装置，其中，所述环境条件检测传感器装置被装在电梯的机房和轿厢移动通道内。

4、按照权利要求 1 的装置，其中，所述第二 CPU 执行部件管理功能，检查和分析功能，报警功能以及监测功能。

5、电梯耐久性的评估方法包括:

检测电梯机房，电梯轿厢，以及电梯运行通道中的环境条件因素;

对具有同样条件的所有电梯采样，并且根据环境因素检测步骤的结果获得一个循环系数，该循环系数涉及在一定环境条件因素下按预定周期出现的可能造成电梯故障的现象;

使循环系数适应实际的条件，从而计算出相对于环境条件因素的期望的故障频率，并且通过把故障频率划分成预定数量的等级来设定一个加权；并且

用基于一个影响因素的电梯部件寿命预测值乘以所述加权，从而为部件计算出一个更新的寿命预测值。

6、按照权利要求 5 的方法，其中，所述循环系数是根据年故障频率，年温差，年平均湿度，以及年平均粉尘污染程度而获得的。

说　　明　　书

电梯耐久性评估装置及其方法

本发明涉及电梯耐久性评估装置及其方法，特别是涉及一种改进的电梯耐久性评估装置及其方法，它能评估电梯主要部件的耐久性。

近来在工业中已经引进了电梯的耐久性评估装置，其作用是收集电梯操作的有关信息并且加以分析，以便更有效地维护电梯。具体地说，现有的电梯耐久性评估装置的基本作用是预测和评估电梯部件的磨损和寿命。

惯用的电梯耐久性评估装置包括一个智能诊断型电梯远程监测系统，它采用局域通信网(LAN)通过一个客户\服务员系统来远程监测电梯的操作状态。另外，电梯耐久性评估装置可以用一个中央处理型管理系统来远程监测电梯的操作状态和性能。根据电梯轿厢的数量及其环境条件，服务员系统也可以用于同一个目的。根据不同的特点，上述服务员系统可以包括各种客户系统。客户系统通过预定的网络与一个子系统进行通信。服务员系统控制从客户系统接收到的所有信息，判断电梯故障的原因，根据判断结果来预测电梯故障，并且针对电梯的操作执行智能诊断，由此可以测出电梯的有效寿命。

在电梯运行期间出现的故障有可能伤害到电梯中的乘客。电梯的故障率是一个很重要的的因素，它是根据电梯轿厢的运行距离及其操作时间来确定的。因此就有可能把上述因素结合在一起预测电梯的故障。为了防止出故障的电梯有可能造成的事故，可能必须要更换造成电梯故障的部件。

因此，对各种因素的检查是很重要的，这些因素有可能是部件之间的异常磨损，来自电梯运行信息的维修年限等等，并且计算出电梯部件的有效寿命。

表 1 表示了可能造成电梯故障的各种因素。通过严密地检查以下这些因素可以预测出电梯部件的有效寿命余额。

表 1

影响因素	寿命评估 部件
运行距离	润滑油，导轨油

总运行时间	制动控制部件
各楼层的运行时间	电缆
各楼层门的开/关次数	与门机构有关的部件
灯的照明时间	灯，稳压器

除了表 1 所示的因素之外还可能有其他影响因素．具体地说，可以根据电梯每日的平均使用时间按照大楼的用途为各种影响因素分类．这种分类被用于确定有关的寿命预测值相对于电梯有效寿命的加权．

表 2 中表示了大楼类型，电梯的每日平均使用类型及其相关的加权．这种加权被用于确定寿命加权，并且上述的加权被用于根据表 1 中所示的因素进行计算，从而确定寿命的预测值．

[表 2]

等级	大楼类型	每日平均使用时间	加权
A	办公	9 小时	1
B	宾馆/百货商店	10 小时	0.9
C	公寓	12 小时	0.75
D	医院/工厂	15 小时	0.6

以下要详细说明采用表 1 的影响因素和表 2 的加权的惯用的电梯耐久性评估装置及其方法．

如图 1 所示，惯用的电梯耐久性评估装置包括一个电梯控制盘 30，监测单元 40，用于通过串行通信链路采集电梯操作信息并且发送电梯的故障和操作状态信息，公共电话网 50 用于把监测单元 40 输出的上述信息发送到相应的部件，远程监测中心 60 用于分析通过公共电话网 50 接收到的信息并且根据分析的结果执行电梯的综合管理，以及一个与监测单元 40 连接的服务站 70，用于执行故障诊断．

远程监测中心 60 包括多个第一中央处理单元(CPU)61，用于构成 LAN(局域网)环境下的客户/服务员系统，以及一个第二 CPU62．

服务站 70 包括与公共电话网 50 连接的第三 CPU71，用于维护和管理电梯系统，以及与远程监测中心的 20 连接的第四 CPU72．

以下参照图 1 说明这种惯用的电梯耐久性评估装置的操作．

首先，电梯控制盘 30 检测安装有电梯的大楼中的影响因素并且把这些因素发送给监测单元 40．例如，可以对运行距离，操作时间及运行频率等影

响因素采样。采样的影响因素信息通过监测单元 40 被发送到远程监测中心 60 的第一 CPU61 .

远程监测中心 60 的第一 CPU61 采集和分析从监测单元 40 发送来的故障和操作状态信息。第二 CPU62 处理这种分析的结果以及与电梯的对应部件有关的信息，并且执行故障诊断的综合管理和部件寿命的评估。具体地说，第二 CPU62 根据第一 CPU61 发送来的信息检查电梯部件的故障与其影响因素之间的关系，这种关系是按预定的间隔产生的。然后，第二 CPU 用检查到的关系作为信息，设定一个与影响因素有关的加权。另外要根据加权计算寿命预测值。诸如故障诊断和寿命评估等电梯的综合管理是根据算出的寿命预测值来执行的。

服务站 70 的第三 CPU71 执行电梯的故障诊断，而第四 CPU72 监测电梯的诊断状态。

如上所述，惯用的电梯耐久性评估装置的基本作用是仅根据诸如电梯运行频率，电梯的操作史，操作时间以及与大楼类型有关的使用因素等等影响因素来预测电梯的寿命。

然而，由于惯用的电梯耐久性评估装置和方法是仅根据影响因素和使用因素来预测电梯主要部件的寿命，这样往往就不能精确地预测出电梯的寿命。另外，由于惯用的电梯耐久性评估装置不考虑电梯的环境条件，例如温度，湿度及粉尘，因此就不能精确地预测出电梯的耐久性。

因此，本发明的目的是提供一种电梯耐久性评估装置及其方法，以便克服惯用的电梯耐久性评估装置的局限性。

本发明的另一目的是提供一种电梯耐久性评估装置及其方法，它能够通过测量装有电梯的大楼中的温度，湿度，粉尘，振动，以及噪声来更精确地预测出电梯部件的寿命。

本发明的再一目的是提供一种电梯耐久性评估装置及其方法，它可以使用改进的耐久性评估方式更加有效地评估电梯的耐久性。

为了实现上述目的，本发明提供的电梯耐久性评估装置包括设置在机房和电梯轿厢中用于检测环境条件因素的环境条件检测传感器，用于控制电梯的控制盘，监测单元，用于把环境条件检测传感器检测到的环境条件因素和控制盘的运行信息通过一个公共电话网发送，以及一个远程监测中心，它包括第一中央处理单元(CPU)，用于从监测单元采集信息并且存储这些信息，

还有一个第二CPU，用于评估部件的耐久性，诊断电梯的故障，以及预测部件的寿命。

为了实现上述目的，本发明还提供了电梯耐久性的评估方法，其中包括检测电梯机房，电梯轿厢，以及电梯运行通道中的环境条件因素，对具有同样条件的所有电梯采样，并且根据环境因素检测步骤的结果获得一个循环系数，该循环系数涉及在一定环境条件因素下按预定周期出现的可能造成电梯故障的现象，使循环系数适应实际的条件，从而计算出相对于环境条件因素的期望的故障频率，并且通过把故障频率划分成预定数量的等级来设定一个加权，并且用基于一个影响因素的电梯部件寿命预测值乘以上述加权，从而为部件计算出一个更新的寿命预测值。

从以下的说明中可以更清楚地看到本发明的其他优点，目的和特征。

通过以下结合附图用举例的方式所做的详细描述可以更清楚地了解本发明，但是这些例子并不是为限制本发明，在附图中：

图1是说明惯用的电梯耐久性评估装置结构的示意图；

图2是用于说明本发明的电梯耐久性评估装置结构的示意图；以及

图3是用于说明本发明的电梯耐久性评估方法的流程图。

图2是用于说明本发明的电梯耐久性评估装置结构的示意图，该装置包括设置在电梯机房100和电梯轿厢122中用于检测电梯附近的各种环境条件的环境条件检测传感器110，用于控制电梯操作的控制盘130，一个监测单元140，用于把由环境条件检测传感器110检测到的环境条件因素和电梯的运行信息通过一个公共电话网150发送到远程监测中心160，而远程监测中心160包括用于从监测单元采集信息并且存储该信息的第一中央处理单元CPU161以及第二CPU162，用于评估部件的耐久性，诊断电梯的故障，以及预测部件的寿命。电梯耐久性评估装置采用公共电话网150把监测单元140输出的信息发送到对应的部件，并且包括一个连接到公共电话网150的服务站170，它用于诊断电梯的故障。

在本发明的电梯耐久性评估装置中，由于远程监测中心160和服务站170具有与惯用的电梯耐久性评估装置相同的结构，在此省略了对其结构的说明。

以下要参照附图说明本发明的电梯耐久性评估装置的操作和效果。

首先，由电梯控制盘130检测电梯所安装的大楼中的影响因素，并且把

这些影响因素发送到监测单元 140．安装在电梯机房 100 和轿厢 122 上部的环境条件检测传感器 110 检测轿厢 122 和电梯系统的轿厢移动通道附近的环境条件因素，诸如温度，湿度，振动，粉尘等等，并且把检测到的环境条件因素发送到监测单元 140．监测单元 140 把影响因素和检测到的环境条件因素和来自控制盘 130 的电梯运行信息一起通过公共电话网 150 发送到远程监测中心 160 的第一 CPU161．

远程监测中心 160 的第一 CPU161 采集和分析从监测单元 140 发送来的影响因素，环境条件因素以及运行信息．第二 CPU162 根据第一 CPU161 的分析结果和电梯的相应部件采集到的信息执行一种有关耐久性评估的算法，以便执行一种综合管理，例如电梯的故障诊断的寿命评估．

换句话说，第二 CPU162 分析电梯部件故障与环境条件因素之间的关系，这种关系是根据第一 CPU161 发送来的信息按预定的间隔形成的，并且用分析的结果作为操作数据，由此来设定与影响因素和环境因素有关的加权．另外，第二 CPU162 用这样设定的加权来校正寿命预测值．第二 CPU162 用这种环境因素下的预测寿命值乘以环境因素的加权，然后计算出更加精确的寿命预测值，从而更加精确的评估电梯部件的耐久性．

第二 CPU162 还执行以下的四种功能：部件管理功能，部件故障检查和分析功能，报警功能，以及监测功能．这里的部件管理功能指的是评估电梯部件的耐久性并且对其进行管理，部件故障检查和分析功能是检查电梯部件的故障，轿厢呼叫状态，专用轿厢的性能，故障频率及其统计，以及检查周期．报警功能的作用是发出一个有关电梯故障的警报，而监测功能是执行远程监测，控制盘的在线控制，以及电梯的在线诊断功能．

因此，如果用环境条件检测传感器 110 检测电梯的环境条件因素，就有可能更精确地预测电梯部件的寿命．

例如，由于在大楼中存在各种环境条件，象惯用的电梯耐久性评估装置那样仅用使用因素的分类不可能精确的评估这些环境条件因素的影响．因此，如上所述，环境条件检测传感器 110 的基本作用是更精确地检测机房 100 和轿厢 122 移动通道中的诸如温度，湿度，粉尘，振动，以及噪声等等环境条件因素．其中的环境监测传感器的作用是监测温度，湿度，粉尘，振动，以及噪声。

以下参照图 3 说明本发明的电梯耐久性评估方法．

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首先，环境条件检测传感器在步骤 S1 中开始工作。为了根据环境条件因素获得加权，要对“n”个采样电梯采样，这些采样电梯具有相同的条件，例如相同的安装日期，系统类型以及用途。在步骤 S2 中检测机房，轿厢及轿厢移动通道中例如温度，湿度，及噪声等环境条件因素。在步骤 S3 中把步骤 S2 检测到的环境条件因素通过监测单元 140 发送到远程监测中心 160 的第一 CPU161 . 然后根据在步骤 S4 中发送的信息模拟电梯部件故障与环境条件因素之间的关系，按预定的周期获得这种关系。然后获得上述模型的循环系数，并将其用于实际的条件，以便设定与环境条件有关的加权。另外，在步骤 S6 中用按照其他诸如运行频率和使用时间等影响因素测得的部件寿命预测值乘以如此设定的加权，从而针对电梯的各个部件计算出优选的寿命预测值执行。最后，在步骤 S7 中根据最后计算出的优选的寿命预测值执行故障诊断和电梯的部件寿命评估等等综合管理。

表 3 表示了关于每个电梯的故障信息和环境条件信息，这些信息是根据对五个电梯的采样获得的。

[表 3]

电梯	年故障率	年温差 (℃)	年平均湿度 (% RH)	粉尘污染等级 ($1000pcs/0.01ft^3$)
1	10	34	37	1.22
2	35	36	39	3.50
3	2	20	29	1.43
4	15	30	33	2.87
5	3	18	30	2.35

对于故障频率来说，为了用环境条件因素计算出影响程度，可以使用以下的公式。

$$y=\alpha+\beta_1 x_1+\beta_2 x_2+\beta\ x_p \qquad \ldots\ldots(1)$$

其中的 y 表示年故障率，α 表示预定的影响常数，x_1 至 x_n 表示变量，β 表示循环系数。在公式中假设 x_1 是温度差，x_2 是年平均湿度，而 x_3 是年粉尘污染程度。公式(1)可以改成以下的矩阵形式。

$$y=x^*\beta \qquad \ldots\ldots(2)$$

$$\begin{pmatrix} 10 \\ 35 \\ \\ \end{pmatrix} \quad \begin{pmatrix} 1 & 34 & 37 & 1.22 \\ 1 & 36 & 39 & 3.50 \\ & & & \end{pmatrix} \quad \begin{pmatrix} \\ \alpha \\ \\ \end{pmatrix}$$

$$\begin{pmatrix} 2 \\ 15 \\ 3 \end{pmatrix} = \begin{pmatrix} 1 & 20 & 29 & 1.43 \\ 1 & 30 & 33 & 2.87 \\ 1 & 18 & 30 & 2.35 \end{pmatrix} * \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix}$$

其中 X 矩阵的第一列与一个常数项相符，表示包括一个常数项的循环模型.

此外，为了预测循环系数(β)，公式(2)可以表示如下:

$\beta = (x'x)^{-1}x'y$

$$x' = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 34 & 36 & 20 & 30 & 18 \\ 37 & 39 & 29 & 33 & 30 \\ 1.22 & 3.50 & 1.43 & 2.87 & 2.35 \end{pmatrix}$$

循环系数(β)是通过把 x， x 的上述矩阵 x'和 y 插入公式(3)而获得的.

$$\beta = \begin{pmatrix} -61.48 \\ 0.25 \\ 1.56 \\ 7.52 \end{pmatrix}$$

如果由循环系数(β)获得了实际的环境条件因素(x_1)，由环境条件因素预测的故障频率(y)可以表示如下.

$y=x_1 * \beta$ ....(4)

在表(4)中表示了从公式(4)获得的加权.

表[4]

预测故障率(Y)	等级	加权
0-5	A	1.0
5-10	B	0.9
10-13	C	0.8
13-	D	0.7

以下要说明参照公式(4)和表(4)获得优选寿命预测值的方法.

首先假设仅根据影响因素获得的部件寿命预测年限是 5，并且电梯的实际环境条件因素的检测值如表 5 所示，预测的故障频率 y 是与循环系数(β)和通过上述矩阵方程获得的公式(4)一起计算的，如下所示.

[表 5]

年温差	年平均湿度	年平均粉尘污染等级
(℃)	(% RH)	($1000pcs/0.01ft^3$)
35	36	1.50

$$y=\begin{pmatrix}1 & 35 & 36 & 1.50\end{pmatrix}*\begin{pmatrix}-61.48\\0.25\\1.56\\7.52\end{pmatrix}$$

$y=14.71$

由此预测出的故障频率(y)是 14.71．另外，在表 4 中与 14.71 的预测故障值相符的加权是 0.7．

因此，优选的寿命预测值是这样获得的，即用预测的故障频率(y)乘以仅根据环境条件因素获得的寿命预测值，如下所示，

$$z=A*W \qquad \text{.........(5)}$$

$=5*0.7=3.5$

其中的 z 表示优选的寿命预测值，A 表示仅根据影响因素获得的寿命预测值，而 W 表示使用环境条件因素获得的加权。

如上所述，本发明的电梯耐久性评估装置及其方法的作用是更精确地预测出电梯的寿命，其作法是检测对电梯部件的寿命影响最大的环境条件因素，并且使用检测的结果进行预测。

本发明的电梯耐久性评估装置及其方法的再一作用是它可以防止电梯的事故，并且更有效地执行维护系统的管理，为电梯部件提供更准确和可靠的寿命预测，并且防止由于电梯部件老化和异常的磨损造成的故障，并且准确地预测出必须要更换的老化部件。

尽管为了说明而描述了本发明的最佳实施例，本领域的技术人员在不脱离权利要求书所限定的本发明范围的条件下仍可以实现各种变更和增删。

图 1

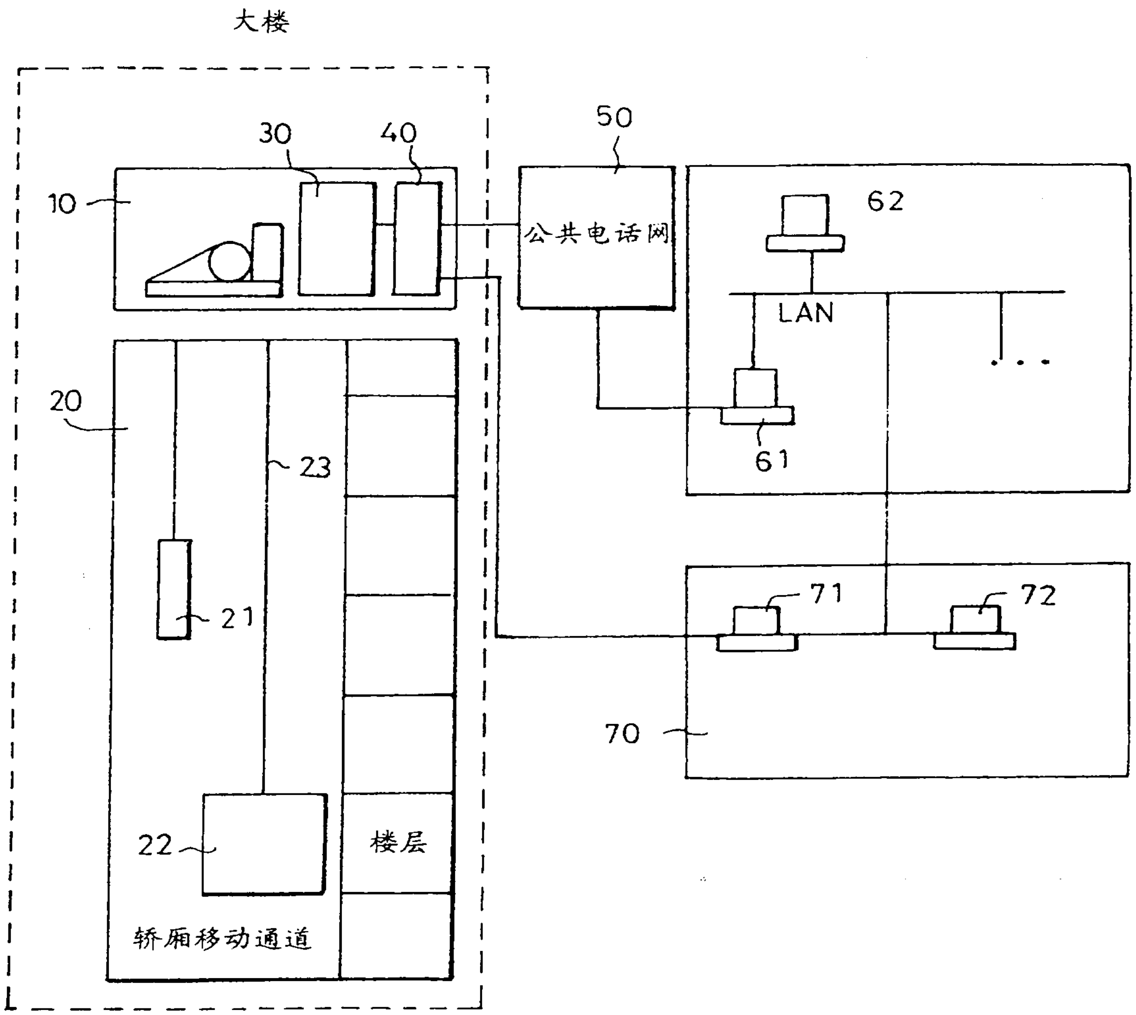

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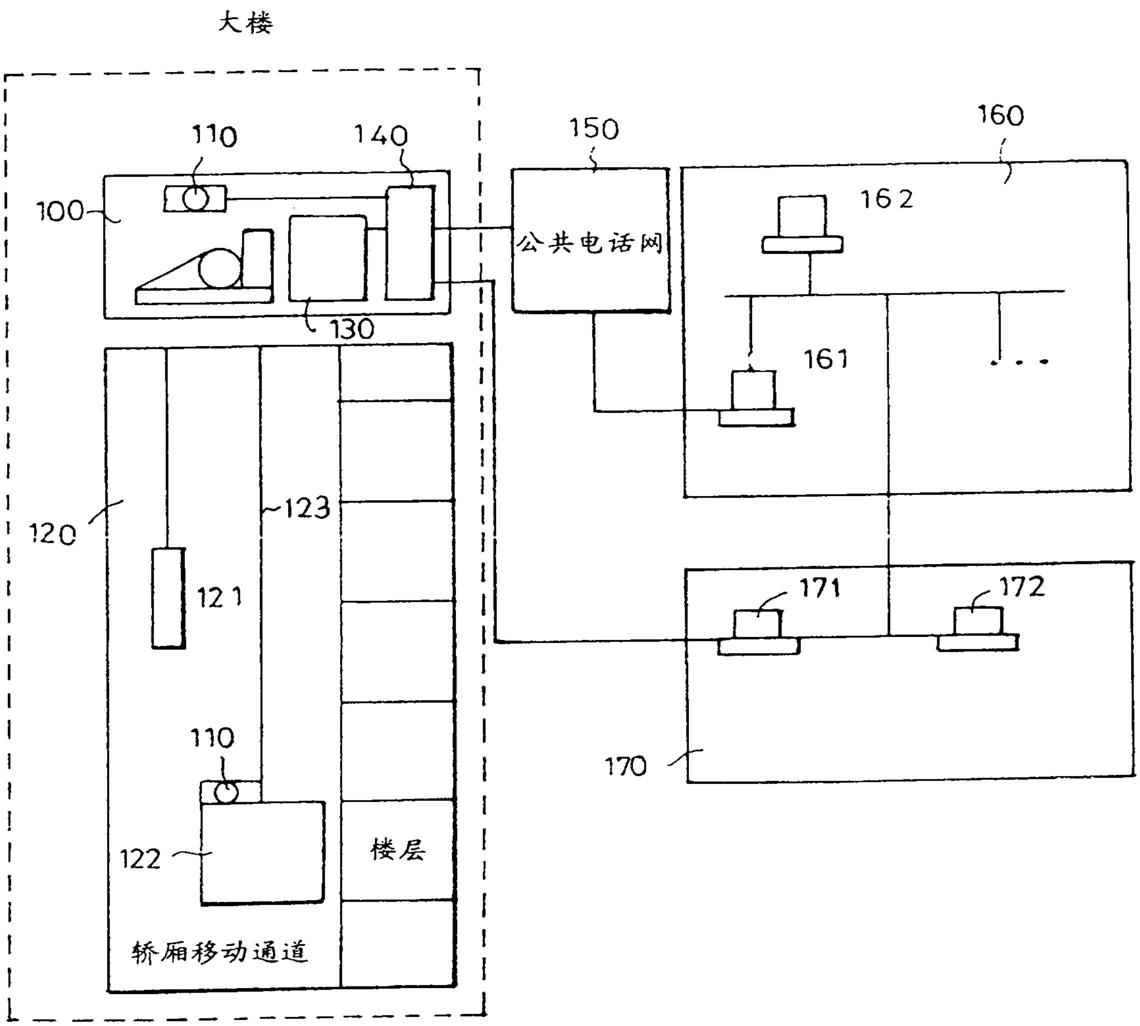
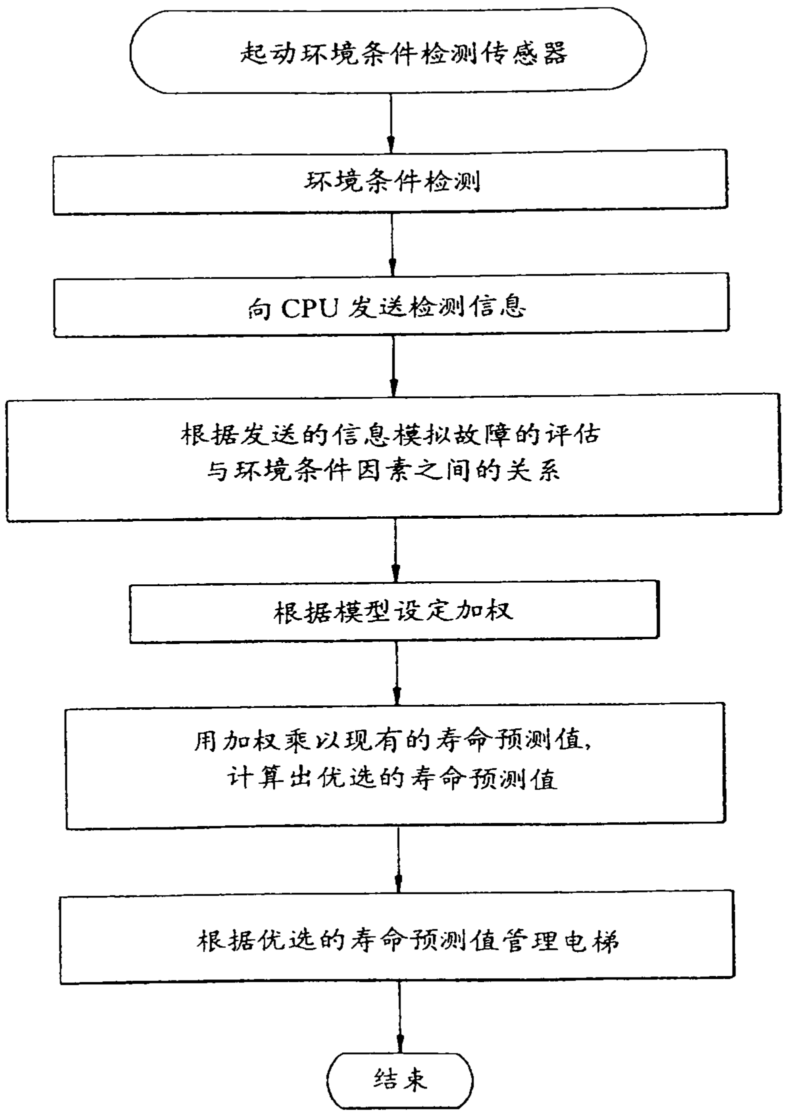
图 2



大楼
110
140
150
160
100
公共电话网
162
130
161
120
123
121
171
172
110
170
122
楼层
轿厢移动通道

图 3


起动环境条件检测传感器
环境条件检测
向 CPU 发送检测信息
根据发送的信息模拟故障的评估
与环境条件因素之间的关系
根据模型设定加权
用加权乘以现有的寿命预测值,
计算出优选的寿命预测值
根据优选的寿命预测值管理电梯
结束

17

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[30] Priority rights

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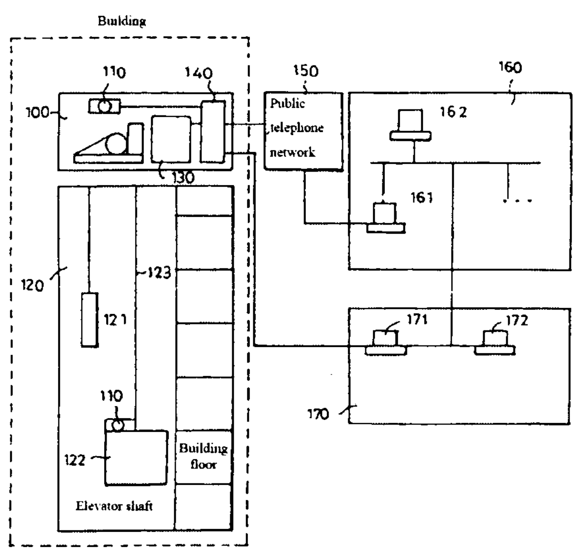
Claims 1 page; Description 8 pages, Drawings 3 pages

[54] Title of invention: Elevator durability assessment device and method thereof

[57] Abstract

An elevator durability assessment device which by measuring the temperature, humidity, dust, vibrations, and noise of the building in which an elevator is installed precisely predicts the life of the elevator's components. It comprises environmental condition sensors set up in the machine room and the elevator car for measuring various environmental condition factors, a control panel for controlling the elevator, and a monitoring unit for sending the environmental condition factor information measured by the environmental condition sensors and operating information from the control panel via a public telephone network to a remote monitoring center. This remote monitoring center includes a first CPU for gathering information from the monitoring unit and storing it and a second CPU for assessing the durability of the components, for diagnosing elevator failures, and for predicting component life.



CLAIMS

1. An elevator durability assessment device, comprising:

environmental condition sensor devices set up in a machine room and in an elevator car for measuring environmental condition factors;

a control panel device for controlling an elevator;

a monitoring unit device for sending the environmental condition factor information measured by the environmental condition sensor devices and operating information from the control panel via a public telephone network to a remote monitoring center; and

a remote monitoring center device, comprising a first central processing unit (CPU) for gathering information from the monitoring unit and storing this information and a second CPU for assessing the durability of the components, for diagnosing elevator failures, and for predicting component life.

2. The device according to claim 1, wherein said environmental condition sensor devices measure temperature, humidity, and the level of dust pollution.

3. The device according to claim 1, wherein said environmental condition sensor devices are installed in the machine room and in the elevator car shaft.

4. The device according to claim 1, wherein said second CPU executes component-management functions, checking and analysis functions, alarm functions, and monitoring functions.

5. An elevator durability assessment method, comprising:

measurement of environmental condition factors in the elevator machine room, the elevator car, and the elevator shaft;

taking samples from all elevators that have the same conditions and, based on the results of the environmental factor measurement step, obtaining a cyclic coefficient, said cyclic coefficient involving phenomena that occur under certain environmental condition factors according to preset periods and that might cause elevator failure;

adapting the cyclic coefficient to actual conditions and calculating expected failure frequencies for corresponding environmental condition factors, and setting a weight by dividing the failure frequencies into grades of preset quantities; and

multiplying said weight by an elevator component predicted life value based on an influencing factor and thus calculating an updated predicted life value for the component.

6. The method according to claim 5, wherein said cyclic coefficient is based on annual failure frequency, annual temperature difference, annual mean humidity, and annual mean dust pollution level.

DESCRIPTION

An Elevator Durability Assessment Device and Method Thereof

The present invention relates to an elevator durability assessment device and a method thereof. In particular, it relates to an improved elevator durability assessment device and a method thereof which can assess the durability of the main components of an elevator.

Elevator durability assessment devices have recently been introduced to the industry. They collect relevant elevator operating information and analyze it in order to maintain elevators more effectively. Specifically, the basic role of existing elevator durability assessment devices is to forecast and assess the wear and tear and life of elevator components.

The conventional elevator durability evaluation device includes an intelligent diagnosis elevator remote monitoring system, which uses a local area network (LAN) to remotely monitor the elevator operating status through a client/server system. In addition, the elevator durability assessment device can use a central processing management system to remotely monitor elevator operating status and performance. A server system can, in accordance with the number of elevator cars and their environmental conditions, be used for a single purpose. Said server system can also include various client systems based on different characteristics. The client systems communicate with subsystems through preset networks. The server system controls all information received from the client systems, determines the cause of elevator failure, forecasts elevator failure based on its determination, and performs an intelligent diagnosis of elevator operations. In this way, it can estimate the effective life of the elevator.

Faults which occur during elevator operation might injure elevator passengers. Elevator failure frequency is a very important factor. It is determined on the basis of elevator car travel distance and operating time. Therefore, it is possible to combine the aforesaid factors to predict elevator failure. To prevent the accidents that might result from elevator failure, it might be necessary to replace the components that would cause elevator failure.

Therefore, it is very important to examine all factors. These factors might include abnormal wear and tear between components and expiration dates from elevator operating information. Moreover, the effective service lives of elevator components need to be calculated.

Table 1 shows the various factors that might cause elevator failure. By meticulously examining each of the factors below, it is possible to predict the remaining effective service lives of elevator components.

Table 1

Influencing factor	Assessed component
Travel distance	Lubricating oil, rail oil
Total travel time	Braking control components
Operating time for each floor	Cables
Number of times door opens/ shuts at each floor	Door mechanism-related components
Lamp illumination time	Lamp, voltage stabilizer

There may be other influencing factors in addition to the factors shown in Table 1. Specifically, it is possible to create classifications for each influencing factor according to building use based on the daily mean elevator operation time. Such classifications are used to weight the relevant life predictions relative to effective elevator life.

Table 2 presents types of buildings, the daily mean elevator operation times, and the weights relating thereto. These weights are used to determine life weights, and the aforesaid weights are used for calculations based on the factors shown in Table 1. In this way, life predications are determined.

[Table 2]

Grade	Building type	Daily mean elevator operation time	Weight
A	Office	9 hours	1
B	Hotel/department store	10 hours	0.9
C	Apartment building	12 hours	0.75
D	Hospital/factory	15 hours	0.6

The following is a detailed explanation of a conventional elevator durability assessment device (and method thereof) that makes use of the influencing factors of Table 1 and the weights of Table 2:

As shown in FIG. 1, the conventional elevator durability assessment device comprises an elevator control panel 30 and a monitoring unit 40, which are for gathering elevator operation information through serial communication links and for sending elevator failure and operating status information. A public telephone network 50 is for sending the aforesaid information output by the monitoring unit to corresponding components. The remote monitoring center 60 is analyzing information received through the public telephone network 50 and, on the basis of the results of the analysis, executing integrated elevator management. A service station 70 is connected to the monitoring unit 40 for performing failure diagnosis.

The remote monitoring center 60 comprises multiple first central processing units (CPU) 61 for constituting the client/server system in an LAN (local area network) environment and a second CPU 62.

The service station 70 comprises a third CPU 71 connected to the public telephone network 50 for maintaining and managing the elevator system and a fourth CPU 72 connected 20 to a remote monitoring center.

The operation of this type of conventional elevator durability assessment device is described below with reference to FIG. 1:

First of all, the elevator control panel 30 measures influencing factors in the building where the elevator is installed, and the data on these factors are transmitted to the monitoring unit 40. For example, samples may be taken of such influencing factors as travel distance, operating time, and travel frequency. The sampled influencing factor information is transmitted to the first CPU 61 of the remote monitoring center 60.

The first CPU 61 of the remote monitoring center 60 gathers and analyzes failure and operating status information sent by the monitoring unit 40. The second CPU 62 processes these analysis results and

information relating to the corresponding components of the elevator. Moreover, it executes integrated management consisting of failure diagnosis and assessment of component life. Specifically, the second CPU 62 examines the relationship between failure of elevator components and the factors influencing them based on information sent from the first CPU 61. This relationship is generated at predetermined intervals. Then, using the examined relationships as information, the second CPU sets weights related to the influencing factors. It also calculates life predictions based on the weights. All integrated management, such as failure diagnoses and life assessments, is executed on the basis of calculated life predictions.

The third CPU 71 of the service station 70 executes elevator failure diagnosis, and the fourth CPU 72 monitors the elevator diagnostic state.

As stated above, the basic role of the conventional elevator durability assessment device is to predict elevator life based on influencing factors such as elevator travel frequency, elevator operating history, operating time, and use factors relating to building type.

However, because the conventional elevator durability assessment device and method predict the lives of major components based on influencing factors and use factors only, they are often imprecise. In addition, because conventional elevator durability assessment devices do not take into account elevator environmental conditions, such as temperature, humidity, and dust, it is not possible to precisely predict elevator durability.

Therefore, an object of the present invention is to provide an elevator durability assessment device and method that overcomes the limitations of the conventional elevator durability assessment device.

Another object of the present invention is to provide an elevator durability assessment device and method that can, by means of temperature, humidity, dust, vibrations, and noise in the building where the elevator is installed, more precisely predict the life of elevator components.

Yet another object of the present invention is to provide an elevator durability assessment device and method that can, through an improved durability assessment method, more effectively assess elevator durability.

To achieve the objects described above, the elevator durability assessment device provided by the present invention comprises an elevator durability assessment device, which includes environmental condition sensors set up in a machine room and in an elevator car for measuring environmental condition factors, a control panel for controlling an elevator, a monitoring unit device for sending the environmental condition factor information measured by the environmental condition sensors and operating information from the control panel via a public telephone network, and a remote monitoring center. This center includes a first central processing unit (CPU) for gathering information from the monitoring unit and storing this information and a second CPU for assessing the durability of the components, for diagnosing elevator failures, and for predicting component life.

To achieve the objects described above, the present invention also provides a method for assessing elevator durability, which comprises the following: measurement of environmental condition factors in the elevator machine room, the elevator car, and the elevator shaft; taking samples from all elevators that have

the same conditions and, based on the results of the environmental factor measurement step, obtaining a cyclic coefficient which involves phenomena that occur under certain environmental condition factors according to preset periods and that might cause elevator failure; adapting the cyclic coefficient to actual conditions and calculating expected failure frequencies for corresponding environmental condition factors and setting weights by dividing the failure frequencies into grades of preset quantities; and multiplying said weights by elevator component predicted life values based on influencing factors and thus calculating updated predicted life values for the components.

The description below will further clarify other advantages, objects, and features of the present invention.

The detailed description below, consisting of examples presented in the light of drawings, allow a clearer understanding of the present invention. However, these examples do not limit the present invention. The drawings:

FIG. 1 presents a diagram of a conventional elevator durability assessment device;

FIG. 2 presents a diagram of an elevator durability assessment device of the present invention; and

FIG. 3 presents a flow chart of an elevator durability assessment method of the present invention.

FIG. 2 presents a diagram of an elevator durability assessment device of the present invention. Said device includes various environmental condition sensors 110 set up in a machine room 100 and in an elevator car 122 for measuring environmental conditions near the elevator, a control panel 130 for controlling elevator operations, a monitoring unit 140 for sending the environmental condition factor information measured by the environmental condition sensors 110 and elevator operating information via a public telephone network 150 to a remote monitoring center 160; and a remote monitoring center 160, comprising a first central processing unit CPU 161 for gathering information from the monitoring unit and storing this information and a second CPU 162 for assessing the durability of the components, for diagnosing elevator failures, and for predicting component life. The elevator durability assessment device uses the public telephone network 150 to send information output from the monitoring unit 140 to the corresponding components. It also includes a service station 170, connected to the public telephone network 150, which is for diagnosing elevator failures.

In the elevator durability assessment device of the present invention, the remote monitoring center 160 and the service station 170 have the same structure as the conventional elevator durability assessment device. Therefore, we will omit a description of this structure here.

The following is an explanation of the operation and results of the elevator durability assessment device with reference to the drawings.

First of all, the elevator control panel 130 measures influencing factors in the building where the elevator is installed and sends this influencing factor information to the monitoring unit 140. The environmental condition sensors 110 installed in the elevator machine room 100 and on top of the car 122 measure environmental condition factors, such as temperature, humidity, vibration, and dust, near the car 122 and the elevator shaft. Moreover, environmental condition factor measurement information is sent to the monitoring unit 140. The monitoring unit 140 sends the influencing factor information, the environmental

condition factor measurement information, and elevator operating information from the control panel 130 together via the public telephone network 150 to the first CPU 161 of the remote monitoring center 160.

The first CPU 161 of the remote monitoring center 160 gathers and analyzes the influencing factor information, environmental condition factor information, and operating information sent from the monitoring unit 140. The second CPU 162, based on the analysis results of the first CPU 161 and information collected on the corresponding components of the elevator, executes a durability assessment algorithm for the purpose of performing a type of integrated management, e.g. longevity assessment from elevator failure diagnosis.

In other words, the second CPU 162 analyzes the relationship between elevator component failure and environmental condition factors. Such a relationship is formed at preset intervals from information sent by the first CPU 161. In addition, using analysis results as operating data, weights are set in relation to influencing factors and environmental factors. In addition, the second CPU 162 uses weights that have been set in this way to correct predicted life values. The second CPU 162 multiplies the predicted life value obtained from such environmental factors by the weight for the environmental factors. Then, it calculates a more precise predicted life value and thereby more precisely assesses the durability of the elevator component.

The second CPU 162 also executes the following four functions: component management function, component failure checking and analysis function, alarm function, and monitoring function. The component management function here refers to assessing the durability of elevator components and managing them. The component failure checking and analysis function checks elevator component failure, elevator car call status, special-purpose car performance, failure frequency and statistics, and the checking cycle. The purpose of the alarm function is to send an elevator failure-related alarm, and the monitoring function executes remote monitoring, control panel online control, and elevator online diagnosis functions.

Therefore, if environmental condition sensors 110 measure environmental condition factors of the elevator, it becomes possible to predict elevator component life with greater precision.

For example, various kinds of environmental conditions are present in a building. Thus, using only use factor classifications as is the case with the conventional elevator durability assessment device cannot precisely assess the impact of these environmental condition factors. Therefore, as stated above, the basic role of the environmental condition sensors 110 is to measure environmental condition factors such as temperature, humidity, dust, vibrations, and noise in the machine room 100 and in the elevator car 122 shaft. Among the roles of an environmental monitoring sensor is the measurement of temperature, humidity, dust, vibrations, and noise.

The elevator durability assessment method of the present invention is explained with reference to FIG. 3.

First of all, the environmental condition sensors begin to operate in step S1. To obtain weights based on environmental conditions, it is necessary to take samples from "n" sample elevators. These sample elevators have the same conditions, e.g. the same installation date, system, time, and purpose. In step S2, environmental condition factors such as temperature, humidity, and noise are measured in the machine room,

elevator car, and elevator shaft. In step S3, the environmental condition factors measured in step S2 are sent to the first CPU 161 of the remote monitoring center 160 via the monitoring unit 140. Then the relationship between elevator component failure and environmental condition factors is simulated based on the information sent in step S4. This relationship is obtained according to predetermined periods. Then, the cyclic coefficient of the above-described model is obtained and applied to real conditions so as to set weights related to environmental conditions. In addition, weights that were established in this way are multiplied in step S6 by predicted component life values measured according to influencing factors such as operating frequency and use time. Thus, preferred predicted life values are calculated for each component of the elevator. Finally, in step S7, integrated management, consisting of failure diagnosis and elevator component life assessment, is executed on the basis of the preferred predicted life values that were finally calculated.

Table 3 represents failure information and environmental condition information for each elevator. This information was obtained from samples taken from five elevators.

[Table 3]

Elevator	Annual failure frequency	Temperature difference (°C)	Annual mean humidity (% RH)	Dust pollution level (1,000 pcs/0.01 ft^3)
1	10	34	37	1.22
2	35	36	39	3.50
3	2	20	29	1.43
4	15	30	33	2.87
5	3	18	30	2.35

To use environmental condition factors to calculate the degree of influence on the failure frequency, the following formula can be used:

$$y=\alpha + \beta_1 x_1 + \beta_2 x_2 + \beta x_p \qquad \text{........(1)}$$

Where y represents the annual failure frequency, α represents a predetermined influencing constant, and x_1 to x_n represent variables, and β represents the cyclic coefficient. Assume that, in the formula, x_1 is temperature difference, x_2 is annual mean temperature, and x_3 is the annual level of dust pollution. Formula (1) can be changed into matrix form, as below:

$$y=x^* \beta \qquad \text{........(2)}$$

$$\begin{bmatrix} 10 \\ 35 \\ \\ \end{bmatrix} \quad \begin{bmatrix} 1 & 34 & 37 & 1.22 \\ 1 & 36 & 39 & 3.50 \\ & & & \end{bmatrix} \quad \begin{bmatrix} \\ \alpha \\ \\ \end{bmatrix}$$

$$\begin{pmatrix} 2 \\ 15 \\ 3 \end{pmatrix} = \begin{pmatrix} 1 & 20 & 29 & 1.43 \\ 1 & 30 & 33 & 2.87 \\ 1 & 18 & 30 & 2.35 \end{pmatrix} * \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix}$$

Where the first column in the X matrix matches a constant term and represents a cyclic model containing a constant term.

In addition, to predict the cyclic coefficient (β), Formula (2) can be expressed as follows:

$$\beta = (x'x)^{-1}x'y$$

$$x' = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 34 & 36 & 20 & 30 & 18 \\ 37 & 39 & 29 & 33 & 30 \\ 1.22 & 3.50 & 1.43 & 2.87 & 2.35 \end{pmatrix}$$

The cyclic coefficient (β) is obtained by inserting x and x' and y of the above matrix into Formula (3).

$$\beta = \begin{pmatrix} -61.48 \\ 0.25 \\ 1.56 \\ 7.52 \end{pmatrix}$$

If the actual environmental condition factor (x_1) is obtained from the cyclic coefficient (β), the failure frequency (y) predicted from the environmental condition factor can be expressed as follows.

$$y = x_1 * \beta \qquad \ldots\ldots\ldots(4)$$

Table (4) presents the weights obtained from Formula (4).

Table [4]

Predicted failure frequency (Y)	Grade	Weight
0-5	A	1.0
5-10	B	0.9
10-13	C	0.8
13-	D	0.7

The following is an explanation of the preferred predicted life values obtained from Formula (4) and Table (4).

First of all, supposing that the predicted component life obtained only on the basis of influencing factors is 5 years, and the actual measured values of elevator environmental condition factors is as shown in Table 5. The predicted failure frequency y is calculated together with the cyclic coefficient (β) and Formula (4) which is obtained through the above matrix equation, as shown below:

[Table 5]

Annual temperature difference (°C)	Annual mean humidity (% RH)	Annual mean dust pollution level (1,000 pcs/0.01 ft^3)
35	36	1.50

$$y = (1 \quad 35 \quad 36 \quad 1.50) * \begin{pmatrix} -61.48 \\ 0.25 \\ 1.56 \\ 7.52 \end{pmatrix}$$

$$y = 14.71$$

The failure frequency (y) based on the above is 14.71. In addition, the weight that matches 14.71 in Table 4 is 0.7.

Thus, this is how the preferred predicted life value is obtained: use the predicted failure frequency (y) to multiply the predicted life that was obtained on the basis of environmental condition factors only. As shown below:

$$z = A * W \qquad \text{.........(5)}$$

$$= 5 * 0.7 = 3.5$$

where z represents the preferred predicted life value, A represents the predicted life that was obtained on the basis of environmental condition factors only, and W represents the weight derived from the from environmental condition factors.

As stated above, the role of the elevator durability assessment device and method thereof of the present invention is to predict elevator life with greater precision. The procedure consists in measuring the environmental condition factors with the greatest impact on elevator component life and providing forecasts on the basis of the measurement results.

Other roles of the elevator durability assessment device and method thereof of the present invention are to prevent elevator accidents and more effectively perform maintenance system management, to provide more accurate and reliable life predictions for elevator components, to prevent accidents caused by component aging and abnormal wear and tear, and to accurately predict aging components in need of replacement.

Although, for the purpose of illustration, we have presented here an optimal embodiment of the present invention, a person skilled in the art would be able to effect various modifications, additions, and deletions without moving beyond the scope of the present invention as defined by these claims.

FIG. 1

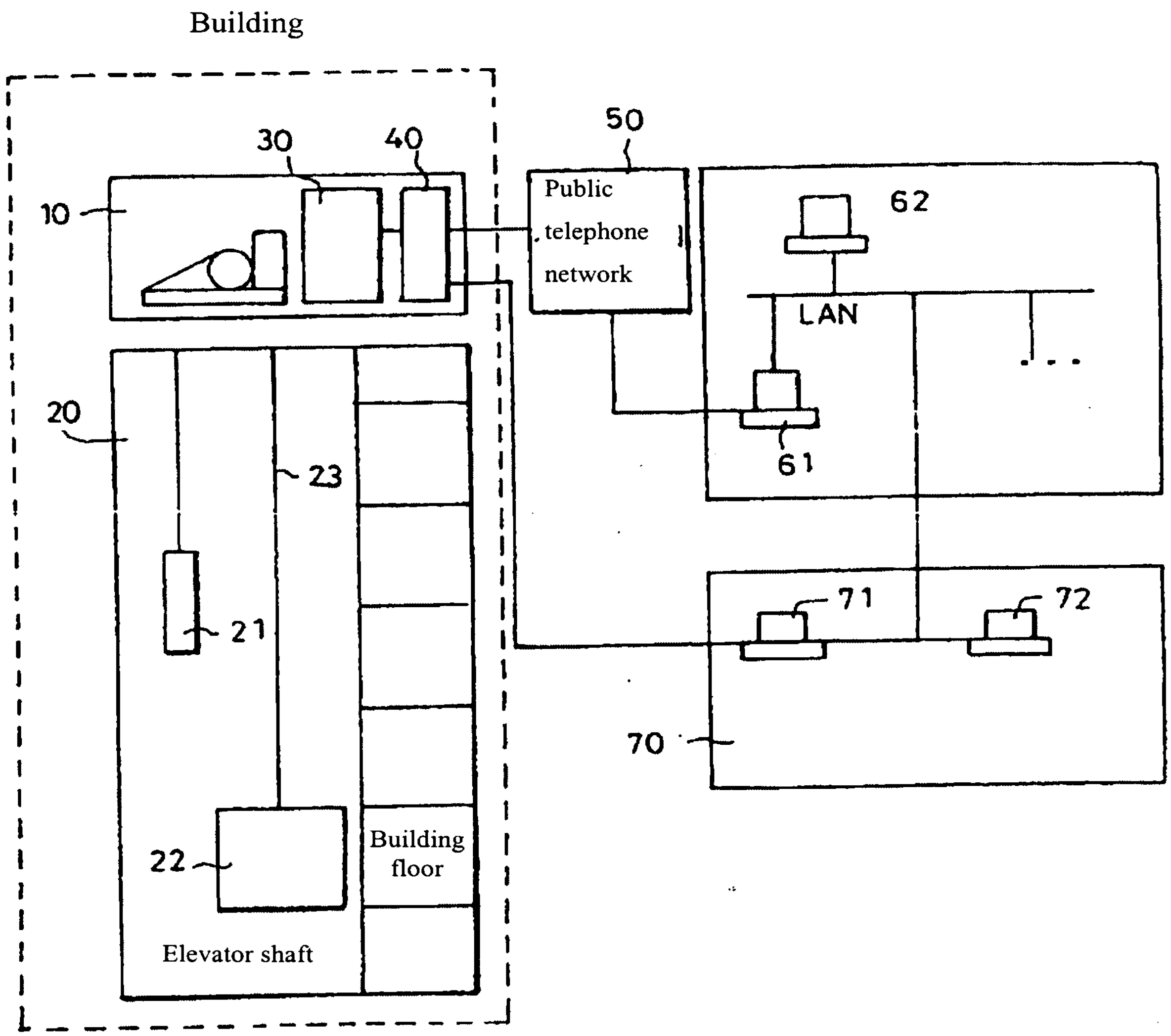
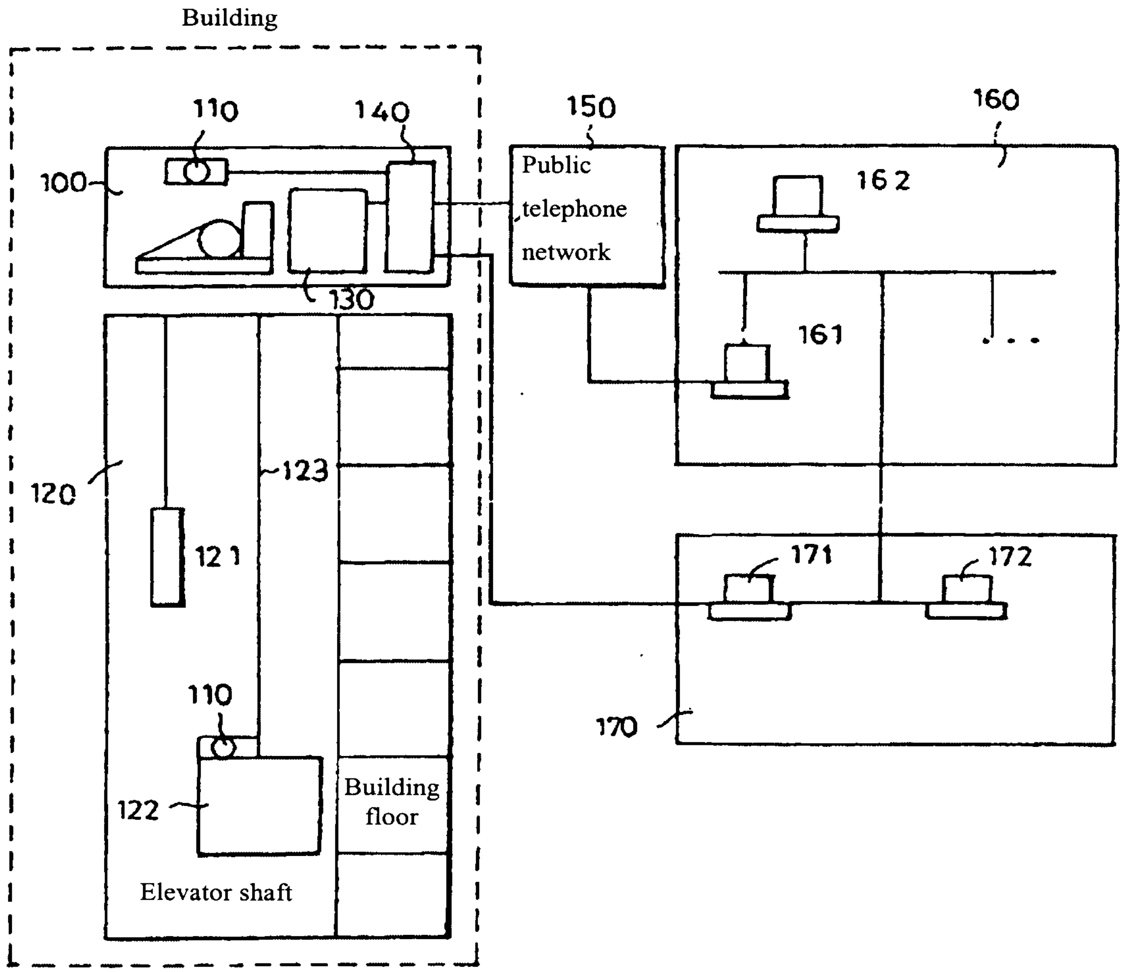
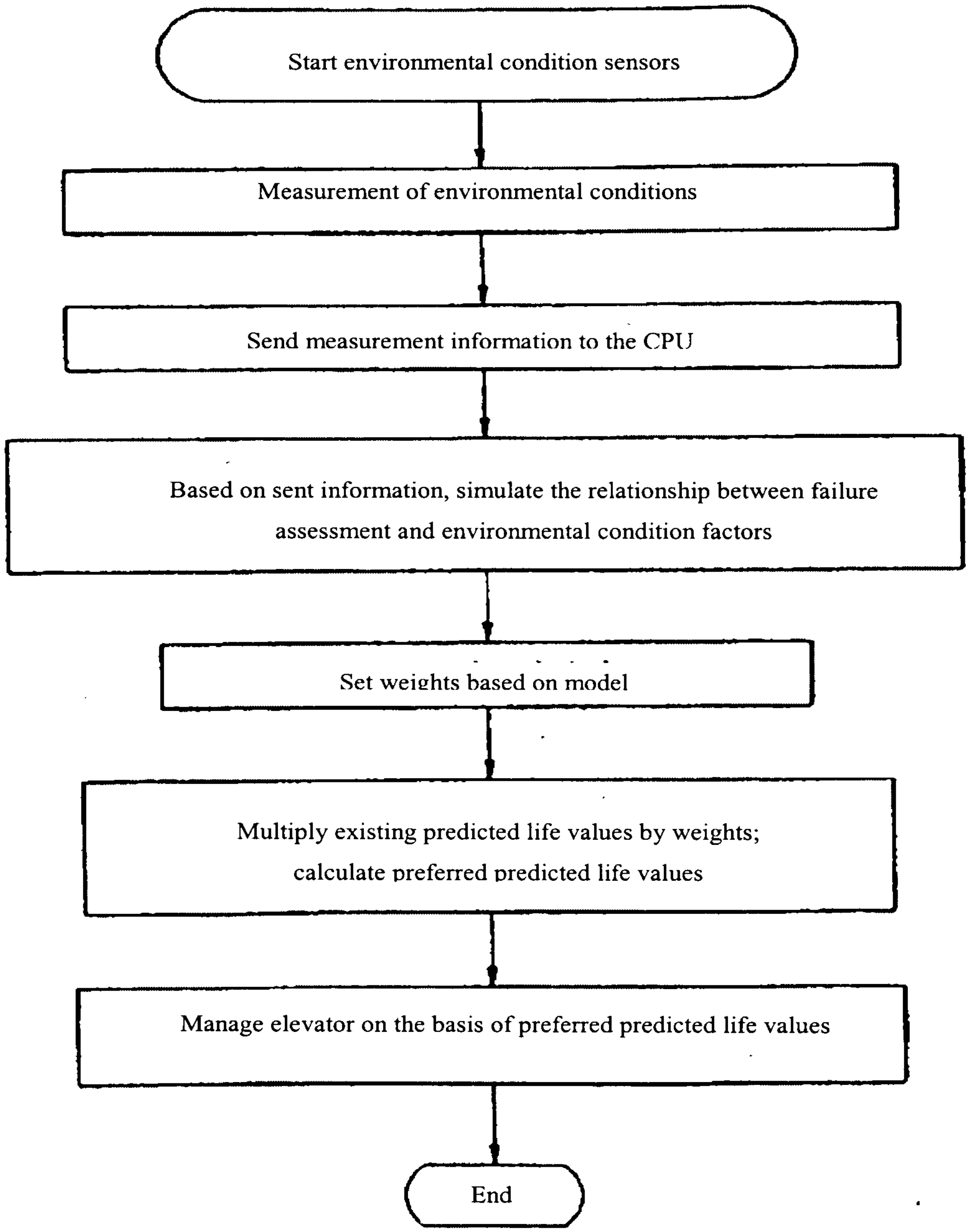

Building
30
40
10
50
Public
telephone
network
62
LAN
61
20
23
21
71
72
70
22
Building
floor
Elevator shaft

FIG. 2



Building
110
140
150
160
100
Public telephone network
162
130
161
120
123
121
171
172
110
170
122
Building floor
Elevator shaft

FIG. 3


Start environmental condition sensors
Measurement of environmental conditions
Send measurement information to the CPU
Based on sent information, simulate the relationship between failure assessment and environmental condition factors
Set weights based on model
Multiply existing predicted life values by weights; calculate preferred predicted life values
Manage elevator on the basis of preferred predicted life values
End